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Research Article

Reducing Traffic Congestion in Hanoi, Vietnam Using Artificial Intelligence and Internet of Things

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Abstract - *Hanoi is one of the largest cities in Vietnam. Traffic congestion is one of the most serious urban transportation problems in Hanoi, Vietnam. Rapid urbanization, increasing private vehicle ownership, limited road capacity, frequent traffic violations, and highly variable traffic demand contribute to long travel times, fuel consumption, air pollution, and reduced quality of life. Traditional traffic management systems based on fixed-time traffic signals and manual monitoring are often unable to respond quickly to changing traffic conditions. Artificial Intelligence (AI) and the Internet of Things (IoT) provide an opportunity to develop a more adaptive and intelligent transportation system. This paper proposes an AI- and IoT-based traffic management solution for Hanoi. The proposed system combines IoT sensors, AI-enabled cameras, GPS/mobile data, edge computing, cloud platforms, adaptive traffic signals, and an intelligent traffic control center. Traffic information is collected continuously and analyzed using computer vision, machine learning, and reinforcement learning. Based on predicted traffic conditions, traffic signals can automatically adjust green, yellow, and red-light durations and coordinate neighboring intersections to create green-wave corridors. The system can also detect incidents, illegal parking, traffic violations, and abnormal congestion and provide real-time information to road users. The proposed approach is supported by recent research on AI, IoT, adaptive traffic signal control, and intelligent transportation systems. Importantly, Hanoi has already begun deploying AI cameras and intelligent traffic control infrastructure. Recent operational results reported by Hanoi indicate substantial improvements in travel time and intersection throughput. The paper therefore combines AI and IoT technologies to significantly reduce the traffic congestion in Hanoi, Vietnam.*

Keywords - *Internet of Things, AI, Traffic Congestion Management.*

I. INTRODUCTION

Hanoi is the capital of Vietnam and one of the fastest growing metropolitan cities in Vietnam. The city has undergone rapid economic growth, urban expansion and increasing levels of travel demand. At the same time, the number of private cars and motorcycles has increased significantly. These factors place considerable pressure on the existing road network. Traffic congestion occurs particularly during morning and afternoon peak periods, at major intersections, around commercial areas, near schools and universities, and on important radial and ring-road corridors. Congestion is not caused by a single factor. It results from the interaction between traffic demand, road capacity, traffic-signal operation, vehicle behavior, parking activity, incidents, construction, weather, and traffic violations. Fig.1 illustrates an example of traffic congestion in Hanoi, Vietnam. Traditional traffic control generally depends on predetermined signal schedules. Such systems work reasonably well when traffic patterns are predictable, but they become less effective when traffic demand changes suddenly. For example, an intersection may receive a large number of vehicles from one direction while the programmed signal continues to allocate the same amount of green time to all approaches. This can lead to long lines in one direction, and empty running in the other. Intelligent Transportation Systems (ITS) try to overcome this limitation by linking cars, roads, sensors, cameras, traffic signals, communication network and control centers. IoT delivers the necessary communication and sensing infrastructure, and AI offers the intelligence to interpret the data gathered and make decisions.

Figure 1. An Example of Traffic Congestion in Hanoi, Vietnam

Research has demonstrated the potential of IoT-based adaptive traffic management systems. An IoT traffic management architecture can gather data from vehicles and infrastructure and send them to intelligent decision making systems [1]. More recent research has investigated deep reinforcement learning (DRL), in which an AI agent learns traffic-signal policies according to traffic conditions [2], [3]. A survey of the DRL-based traffic signal control shows that adaptive AI control may be able to decrease delay and enhance traffic flow, but the shift from simulation to real-world networks is a significant challenge [4]. The Hanoi context is even more intriguing, given Hanoi's shift toward intelligent traffic management. Hanoi's intelligent traffic-control program includes AI cameras, traffic monitoring, violation detection, and adaptive traffic-signal control. The city's intelligent transportation plan also identifies functions including traffic monitoring, traffic control, public transport management, parking management, incident management, infrastructure management, and traffic simulation [5].

In January 2026, Hanoi reported that its AI camera system had been operating with approximately 1,837 cameras at 195 major intersections and 25 major streets. The system can collect traffic information and support real-time signal control. Reported results included travel-time reductions of approximately 31–36.8% on one-way roads and 20–25% on heavily trafficked two-way roads, together with increases in intersection throughput [6]. Therefore, the main objective of this paper is to develop a practical framework for reducing traffic congestion in Hanoi through the integration of AI and IoT. The proposed system builds on existing infrastructure while introducing predictive analytics, adaptive signal optimization, edge computing, multimodal transportation data, and coordinated corridor management.

II. RELATED WORKS

Traffic congestion has become a major challenge in rapidly urbanizing cities such as Hanoi, where high traffic demand, heterogeneous vehicle flows, frequent congestion at intersections, and limited road capacity make conventional fixed-time traffic signal control increasingly ineffective. Early intelligent traffic-management research focused mainly on adaptive control, allowing signal timings to respond to changing traffic conditions rather than relying on predetermined schedules. Abdulhai et al. [7] investigated reinforcement learning for adaptive traffic signal control and demonstrated the potential of Q-learning to dynamically select signal-control actions according to the observed traffic environment. Their work established an important foundation for subsequent AI-based traffic signal control because the controller could learn an appropriate policy instead of relying entirely on predefined traffic models.

For the Vietnamese context, Phan et al. [8] proposed an IoT-based intelligent traffic-light system combined with the green-wave theory. The system collected traffic conditions from multiple intersections through an IoT platform and centrally controlled traffic signals. A programable logic controller was used at intersections to acquire traffic parameters and send them to a central operation system. The solution showcased the benefits of IoT in delivering real-time data infrastructure for smart traffic management in the context of Vietnamese cities. The control strategy, however, was mainly developed with the purpose of optimizing green waves, instead of a learning-based AI model, which did not allow for autonomous adaptation to highly dynamic traffic conditions.

Fuzzy logic was subsequently investigated as an alternative for dealing with the uncertainty and variability of urban traffic. Nguyen et al. [9] developed a fuzzy traffic signal control method for a single intersection under mixed traffic conditions and evaluated it using a typical intersection in Hanoi. The method dynamically adjusted the green-light duration according to traffic conditions and achieved lower average delay than the existing signal-control strategy in simulation. The study is particularly relevant for Hanoi, as the traffic is made up of a variety of vehicles, including motorcycles, cars, buses and trucks, making the traditional traffic models less applicable to local traffic.

Vuong et al. [10] also designed an adaptive neuro-fuzzy inference system (ANFIS) for an isolated intersection in Hanoi. They used a neural-network learning system to learn fuzzy-inference rules for determining proper green time periods based on the changing traffic volume. The proposed system has been assessed in VISSIM and MATLAB and has shown improved adaptability and traffic performance compared to fixed-time and conventional fuzzy-control methods. This study represents an important transition from rule-based fuzzy control toward data-driven AI-based traffic signal optimization for Hanoi. Nevertheless, the system focused on an isolated intersection, while congestion in Hanoi is often caused by interactions among multiple neighboring intersections.

As deep learning became increasingly integrated with reinforcement learning, DRL emerged as a promising solution for complex traffic-control problems. Rasheed et al. [11] conducted an extensive review of DRL application on traffic signal control, which demonstrated that DRL can learn traffic signal control policies directly from high-dimensional traffic states and it can alleviate some of the issues of the conventional model-based approaches. Other challenges found by the review included: Multi-intersection coordination, training complexity, simulation-to-real-world transfer, and the availability of reliable traffic data. These issues are very significant for Hanoi, where the practical application of an AI traffic-control system is to be realized within very dynamic and heterogeneous traffic conditions.

Haddad et al. [12] extended DRL toward cooperative control of multiple intersections. Their method formulated traffic signal control as a multi-agent reinforcement learning problem in which individual agents controlled different intersections while exchanging information about neighboring traffic states, actions, and rewards. The cooperative approach improved average waiting time, queue length, and CO_2 emissions compared with several existing methods, particularly under congested conditions. Such multi-agent coordination is potentially suitable for Hanoi because congestion frequently propagates between adjacent intersections rather than occurring independently at a single junction.

Ren et al. [13] subsequently proposed a two-layer coordinated reinforcement-learning framework for traffic networks. The method combined local cooperation among neighboring intersections with global coordination across the network, while simultaneously considering traffic congestion and vehicle emissions. Experiments using synthetic networks and the Cologne urban network demonstrated the potential of coordinated multi-agent learning for large-scale traffic management. This approach suggests a possible direction for Hanoi in which local intersection controllers can cooperate while receiving information from a city-level traffic-management platform.

More recent research has focused on improving the robustness and convergence of DRL-based traffic signal control. Cai and Wei [14] proposed an enhanced DRL method incorporating double Q-learning, a dueling network, prioritized sampling, and noise parameters. Their approach was designed to improve training efficiency and robustness under different traffic-flow conditions, and experiments showed improvements in queue length and waiting time. Such methods are promising for Hanoi because traffic patterns can change substantially between peak and off-peak periods and because a traffic-control model must remain effective under different demand conditions.

The research trend has also shifted toward integrating multiple AI techniques with adaptive traffic signal control. Agrahari et al. [15] investigated the adaptive traffic signal control techniques involving fuzzy logic, reinforcement learning, deep reinforcement learning, metaheuristic optimization and hybrids. Their review underscored the need to transition from isolated intersections to multi-intersection coordinated systems, and to real time traffic information. The development is especially important for Hanoi where a congestion-reduction system should be based on a network-level coordination and adaptive decision-making, not on optimizing individual intersections separately. Lastly, the debate regarding the fusion of AI, Internet of Things (IoT) and predictive analytics for smart mobility in the cities has gained momentum in recent times. Gheorghe and Soica [16] reviewed AI- and IoT-enabled adaptive traffic-control systems and highlighted the role of IoT sensors in continuously collecting traffic information, while AI models process these data to support real-time signal optimization, traffic prediction, vehicle coordination, and emergency response. This integrated architecture is highly relevant to Hanoi because IoT can provide the sensing and communication infrastructure while AI can transform real-time traffic data into adaptive control decisions.

III. PROPOSED SOLUTIONS

This section presents the solutions to reduce the traffic congestion using AI and IoT technologies.

A. AI Solutions to Reduce the Traffic Congestion

Artificial Intelligence (AI) provides an effective approach for reducing urban traffic congestion by enabling traffic-management systems to learn from historical and real-time traffic data and make adaptive decisions. Conventional traffic-control systems rely on fixed signal durations, which cannot effectively adapt to the complex traffic patterns of urban areas. AI-driven systems can analyse these patterns and automatically adjust traffic-light durations based on real-time conditions. For Hanoi, where traffic demand varies significantly between peak and off-peak periods and where motorcycles, cars, buses, and trucks share the same road network, AI can provide more flexible traffic-management capabilities.

One important AI solution is machine-learning-based traffic prediction. Machine-learning models such as Random Forest, Support Vector Regression, XGBoost, LightGBM, and Artificial Neural Networks can be trained using historical traffic data to predict traffic volume, vehicle speed, travel time, and congestion levels. Traffic management systems can predict congestion before it gets to an extreme stage, enabling them to adjust signal durations, route traffic around the road network and issue warnings to road users. Time-series models, like Long Short-Term Memory (LSTM) networks, are especially appropriate as traffic conditions have strong temporal dependencies. An LSTM model can learn traffic patterns from previous time intervals and predict future traffic conditions for individual roads or intersections.

Another important AI solution is intelligent traffic signal control. Reinforcement learning (RL) and Deep Reinforcement Learning (DRL) allow traffic signal controllers to learn appropriate actions from interactions with the traffic environment. The traffic state can include queue length, vehicle density, waiting time, and traffic flow, while the actions can include changing the signal phase or extending and reducing green-light duration. The goal function may be optimized for reduced vehicle wait time, reduced queue length, reduced travel time, or a combination of these. DRL methods are of great promise, as their deep neural networks can capture complex relationships between traffic states and control actions.

AI can also be applied to traffic-flow optimization and route recommendations. A central traffic-management system can analyze traffic conditions across multiple roads and recommend routes that reduce congestion. Graph Neural Networks (GNNs) are increasingly suitable for this task because a road network can naturally be represented as a graph, where intersections are nodes and roads are edges. Combining GNN-based components with recurrent or attention-based ones can account for spatial connections among adjacent roads and intersections, and temporal traffic changes. This enables congestion prediction to consider both the current traffic condition and congestion propagation from neighboring locations.

Another key AI solution is computer vision. The video streams of the cameras set at intersections can be analyzed by object-detection models like YOLO, Faster R-CNN or other light-weight deep-learning networks. The models can identify and categorize vehicles, estimate traffic volumes, calculate the length of the traffic queue, detect idling vehicles and detect incidents, including accidents and unusual traffic patterns. Compared with manually collected traffic information, AI-based video analysis can continuously provide detailed traffic information without requiring physical sensors for every vehicle.

For Hanoi, AI solutions should also consider heterogeneous traffic conditions. The large proportion of motorcycles creates traffic-flow characteristics that differ from those of cities dominated by passenger cars. Therefore, AI models should be trained using local traffic data and should explicitly consider different vehicle classes. A practical AI-based congestion-reduction system could combine traffic prediction, computer vision, reinforcement learning, and route optimization. Historical and real-time data could first be used to predict congestion, after which an AI controller could optimize traffic signals and recommend alternative routes.

Despite their potential, AI-only solutions have an important limitation: they require reliable and continuous data. An AI model cannot make accurate decisions if traffic information is incomplete, delayed, or inaccurate. Consequently, AI should be supported by an appropriate sensing and communication infrastructure. This limitation motivates the use of IoT technologies to continuously collect traffic data from roads and intersections and transmit these data to AI-based traffic-management systems.

B. IoT Solutions to Reduce the Traffic Congestion

The Internet of Things (IoT) provides the sensing, communication, and data-exchange infrastructure required for intelligent traffic management. An IoT-based transportation system connects physical devices, sensors, vehicles, traffic lights, cameras, and communication networks to continuously collect and exchange information. The IoT technology, unlike traditional traffic-management systems, which relies on periodic manual surveys or a fixed signal plan, allows traffic conditions to be monitored in near real time. This is especially helpful in Hanoi as traffic situations can be fluid and unpredictable, influenced by factors such as heavy traffic, accidents, weather conditions, and fluctuating demand.

One important IoT solution is the deployment of traffic sensors at intersections and along major roads. Vehicle volume and speed, as well as vehicle occupancy, queue length, and other traffic parameters can be measured using sensors. Different sensing technologies can be used depending on the road environment and cost requirements, including inductive loops, infrared sensors, ultrasonic sensors, radar sensors, Bluetooth/Wi-Fi detectors, and video cameras. The collected information can be transmitted through IoT communication networks to a central traffic-management platform. This enables traffic authorities to have an ongoing view of traffic patterns throughout their road network.

Another effective solution is the smart traffic lights that are powered by the Internet of Things. Traditional traffic lights are programmed to follow fixed timings and are not able to adapt flexibly to traffic demand changes. IoT-enabled traffic signals can receive traffic information from connected sensors and dynamically modify signal timings. For example, when sensors detect a long queue on one approach of an intersection, the system can increase the corresponding green-light duration. Similarly, if an approach has very low traffic volume, its green time can be reduced. Multiple intersections can also exchange information through an IoT network to support coordinated traffic-signal operation. IoT can also enable connected vehicles and vehicle-to-infrastructure communication. Communication devices in vehicles transmit information related to position, speed, direction and travel status to roadside infrastructure. Traffic-management centers can aggregate these data to obtain a more comprehensive understanding of traffic conditions. In addition, traffic authorities can send information back to connected vehicles, including congestion warnings, recommended routes, accident notifications, and information about traffic-signal changes. This communication can enhance traffic efficiency and road safety.

Real-time incident detection is another IoT use case. An IoT system can always monitor roads to find out abnormal situations like accidents, stopped vehicles, road blockage, and slow traffic. Once an incident is detected, the information can be transmitted to a traffic-management center. Authorities will then be able to react faster by dispatching emergency services, changing traffic signals, or giving alternative-route information. Early detection and response can help avoid local congestion from becoming widespread.

IoT infrastructure also can facilitate smart parking and traffic-demand management. Parking sensors can identify if a parking space is empty and report back to a central system. Drivers can then receive information about available parking locations, reducing the amount of time spent searching for parking. This can help to eliminate unnecessary vehicle movement in densely-populated cities like Hanoi, which in turn can help to alleviate congestion and congestion costs within the city.

An IoT-only traffic-management system, however, is mainly about data collection and communication. While IoT offers vast amounts of real-time data, it does not include sophisticated reasoning or optimization features. Large amounts of sensor data must be analyzed to determine appropriate traffic-control actions. Therefore, IoT infrastructure should be combined with AI algorithms capable of predicting traffic conditions, detecting patterns, and optimizing traffic-control decisions. The combination of these two technologies can create a smarter, more autonomous traffic-management system.

C. Combination of AI and IoT Solutions to Reduce the Traffic Congestion

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) provides a comprehensive approach to intelligent traffic management. IoT is the sensing and communication infrastructure enabling continuous collection of traffic information, and AI is the technology used to analyze traffic data and make decisions on traffic-management actions. Therefore, the combination of AI and IoT can transform a conventional traffic-control system into an adaptive, predictive, and potentially autonomous transportation system. This is especially suitable for Hanoi due to the highly dynamic traffic pattern in the city with mixed traffic flow.

An AI-IoT traffic-management architecture typically consists of four layers: the sensing layer, communication layer, intelligence layer, and application/control layer. At the sensing layer, IoT devices such as cameras, radar sensors, inductive-loop detectors, GPS devices, and connected vehicles collect traffic information. Common parameters are vehicle volume, vehicle speed, density, vehicle queue, vehicle type and location. These data are sent to the edge devices or to a central traffic-management platform using wireless and wired communications. The intelligence layer leverages AI models to evaluate the gathered data, identify unusual events, and make informed decisions regarding traffic control. Finally, the application/control layer applies the AI decisions to traffic lights, route recommendations, variable message signs, and other transportation services.

One important application is AI-based adaptive traffic signal control using IoT data. IoT sensors continuously provide traffic states at intersections, while an AI controller uses these states to determine the optimal signal phases. For example, a reinforcement-learning agent can receive queue lengths and traffic volumes from multiple approaches as its state. It can then choose actions like extending the current green light, adjusting the signal duration, or controlling the traffic signal with adjacent intersections.The reward function can be designed to minimize total waiting time, queue length, travel time, and unnecessary stops. This enables traffic signals to adapt automatically to real-time traffic conditions.

A second application is real-time congestion prediction. IoT devices continuously generate traffic data that can be stored in a traffic database. AI Traffic prediction can be carried out several minutes ahead by using AI models like LSTM, GRU, XGBoost, LightGBM, or Graph Neural Networks, which can leverage historical and real-time observations. The model can predict congestion at a certain intersection, and the traffic-management system may modify the signal timing or suggest alternate routes before serious congestion occurs. This changes traffic management from a reactive approach to a predictive approach.

Coordinated multi-intersection control is another advantage of integrating AI and IoT. Instead of optimizing each intersection independently, IoT devices can exchange traffic information among neighboring intersections. The AI-based multi-agent reinforcement learning can then manage the traffic signals throughout the network. An intelligent agent may be used to represent each intersection to observe local traffic conditions and receive information from other agents in the neighborhood. This will help mitigate the propagation of queues through intersections and help to enhance traffic flow along major corridors.

Combining computer vision and IoT is also possible for automated traffic monitoring. At intersections, cameras can feed streams of video data into edge-computing devices, which can then be used to classify and identify vehicles using AI models. Edge AI can shorten communication latency, as it processes video data in the field, instead of sending all video data to a central server. The extracted information, such as vehicle counts, queue lengths, and traffic density, can then be transmitted to the central traffic-management system. This topology can help lower bandwidth usage and provide almost real-time traffic control.

For Hanoi, a practical AI-IoT system could integrate roadside cameras, traffic sensors, GPS information from public and private vehicles, weather information, and traffic-signal controllers. The IoT devices would gather traffic information on major roads and intersections on a continuous basis. These data would be used to update AI models, which would then analyse them to estimate the current state of traffic and predict future congestion. An optimization or reinforcement learning module could then be used to decide on signal timing and route controlling strategies. The system could also provide congestion information to drivers through mobile applications or variable message signs.

The major advantage of the AI-IoT approach is the closed-loop operation of sensing, communication, prediction, decision-making, and control. The traffic conditions are sensed by the IoT devices, communicated via the communication infrastructure, processed by the AI models, and translated into control actions. The result of the traffic conditions is then sensed again, and the system continues to update its decision as the traffic conditions change. A closed-loop system may offer more adaptability than either AI or IoT.

Nevertheless, several challenges must be addressed before large-scale deployment in Hanoi. These include sensor reliability, communication latency, data quality, cybersecurity, privacy, computational requirements, and the need for large-scale local traffic datasets. In addition, AI models trained in other cities may not perform reliably under Hanoi's heterogeneous traffic conditions. Therefore, the proposed system should be trained and evaluated using real traffic data collected from Hanoi and should be designed to support incremental deployment. Overall, the integration of AI and IoT provides a promising foundation for developing a scalable smart-traffic system capable of reducing congestion, improving travel efficiency, and supporting intelligent transportation management in Hanoi.

IV. THE DEVELOPMENT OF THE SOLUTIONS IN HANOI, VIETNAM

Hanoi has gradually shifted from conventional traffic-management methods toward intelligent transportation systems (ITS), with increasing use of sensors, cameras, communication technologies, artificial intelligence (AI), and real-time traffic control. In the early stages, traffic congestion was mainly addressed through infrastructure expansion, conventional traffic signals, manual traffic control, and fixed-time signal plans. They were relatively easy to run and inadequately able to cope with the rapidly changing traffic demand. The increasing number of vehicles and the heterogeneous traffic composition of Hanoi, particularly the large proportion of motorcycles, created a need for more adaptive traffic-management technologies.

The development of intelligent traffic solutions initially focused on collecting traffic information and improving coordination between intersections. IoT technologies were a significant building block, facilitating the sharing of data between traffic sensors, cameras, signal controllers, and communication devices. Specifically, the study has explored traffic-light systems and green-wave schemes in the context of urban traffic in Vietnam by using IoT.

These systems illustrated that real-time traffic information could be utilized to coordinate traffic lights and optimize the flow of vehicles in the main corridors. The study of fuzzy logic and adaptive neuro-fuzzy inference systems (ANFIS) for traffic signal control was then undertaken specifically for Hanoi, with the results showing the potential for intelligent controllers to adapt signal timing to variable traffic conditions.

Hanoi has subsequently moved toward a city-scale smart-traffic strategy. In 2024, the city approved its Smart Transportation Project for the 2024--2030 period, with a vision toward 2045. The project planned the development of an integrated intelligent traffic operation center with functions including traffic monitoring, traffic-information provision, traffic control, public transportation management, parking management, incident management, and traffic-infrastructure management. The initial phase also included the deployment of intelligent transportation-system equipment at major intersections and roads. Later phases planned to expand intelligent traffic infrastructure to cover a much larger proportion of the city's road network.

In 2025, a significant change was the rollout of AI-powered traffic cameras and real-time intelligent traffic signal control. In December 2025, Hanoi officially opened a new traffic-control centre that combines AI traffic management. The system integrated 1,837 cameras and 188 AI support traffic-signal control cabinets. In addition, 957 cameras were installed at 195 signalized intersections to provide real-time traffic-flow information. The system was designed to reveal not only traffic violations, but also congestion and to create green wave corridors as well as to shorten or extend signal durations depending on traffic demand.

Figure 2. Example of the Application of AI Solution to Reduce traffic Congestion in Hanoi, Vietnam

The initial results indicate the practical potential of this AI-based approach. Six green-wave corridors were established on major streets, and the Hue, Hang Bai (Hanoi) corridor demonstrated a 31% reduction in travel time compared with the previous traffic-control system. The system also reduced the number of stops at intersections, shortened queues at red lights, and improved traffic flow through intersections. Hanoi reported positive results in traffic throughput and travel time on several monitored corridors after about a month of operation, including travel time reductions of about 31-36.8% on some one-way corridors and intersection throughput increases of up to 13-18.88%.

In 2026, the development continued with the further expansion and refinement of traffic monitoring based on AI. A six-month pilot using AI cameras on Vo Chi Cong and Pham Van Dong (Hanoi) streets demonstrated the ability to collect traffic-flow information, count vehicles by lane, monitor lane violations, and support traffic analysis. In July 2026, Hanoi further introduced electronic traffic-information displays and an AI virtual assistant for traffic management. The system was reported to operate with nearly 5,000 AI cameras and could analyze and summarize real-time traffic information to support traffic-control decisions.

V. CONCLUSION

Traffic congestion is a complex problem that cannot be solved by road construction alone. Hanoi requires a transportation system capable of continuously observing traffic, predicting future conditions, and adapting to changing demand. This paper proposed an integrated AI and IoT solution consisting of AI cameras, IoT sensors, GPS/mobile data, edge computing, traffic prediction, adaptive traffic-signal control, green-wave coordination, incident detection, intelligent parking, and centralized traffic management.

The next step should therefore be to move from individual AI applications toward a fully integrated, predictive, network-wide intelligent transportation system. Such a system should combine real-time IoT data, AI forecasting, reinforcement learning, digital twins, connected vehicles, public transportation, and human supervision. If implemented carefully, AI and IoT can help Hanoi reduce congestion, shorten travel time, improve road safety, reduce emissions, improve emergency response, and provide a foundation for a smarter and more sustainable urban transportation system.

Conflicts of Interest

The authors declare that there is no conflict of interest concerning the publishing of this paper.

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